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Comparative evaluation of transhipment technologies for intermodal transport and their cost

Executive Summary

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INTRODUCTION

Freight transport and logistics are essential for the economic activity in the Single Market and quality of life in Europe at large. In 2019, the sector generated approximately EUR 675 billion of gross added value or about 5% of the EU's total Gross Domestic Product. While statistics on emissions from freight transport and logistics at EU level are not available, model estimates indicate that freight transport currently contributes over 30% of CO_2 emissions from transport[1] and EU freight transport activity is projected to grow by close to 50% by 2050, relative to 2015. To address this, the EU climate and transport policies have set targets to reduce the transport emissions by various initiatives, including through making wider use of more-sustainable modes of transport and in particular multimodal and intermodal transport.

This study focus on intermodal transport. Intermodal transport is the movement of goods (in one and the same loading unit or a vehicle) by successive modes of transport without handling of the goods themselves when changing modes.[2]

In order to better understand the competitiveness and effectiveness of different ways to carry out intermodal transport, this study gathers detailed information on different intermodal transhipment technologies and their use for transhipment and transport of different types of loading units, and analyses their use and potential on the TEN-T network. The study also assesses the competitiveness of the intermodal transport per unit transported when compared to road-only transport for the same distance.

TRANSHIPMENT TECHNOLOGIES AND INTERMODAL LOADING UNIT COMBINATIONS

The study looks at four standard types of intermodal loading units: containers, swap bodies, semi-trailers and full road vehicles – as well as their sub-categories – and identified their main specific features. A total of 48 different types of intermodal loading units were identified, including the number of such loading units in circulation and the relevant technical information such as external and internal dimensions, weight, area and volume, capacity for pallets as well as their craneability and stackability.

For containers it is estimated that around 38 million TEU are in service around the world. As containers are also used in intercontinental transport, they are not fixed to any one region and providing a figure for Europe alone is impossible. It is however certain, that containers are the most widely used and available type of loading unit used in European intermodal transport. Swap bodies and semi-trailers are usually used only in continental intermodal transport (intermodal transport not serving maritime transport). The total number of swap bodies in circulation in the EU is estimated to be between 300.000 and 400.000 units. As regards semi-trailers, around 2.8 million units are registered in the EU, however the vast majority of these is likely never used in intermodal transport but in road transport only. No data exists on the share of craneable compared to non-craneable semi-trailers in the EU. For the analysis of different transhipment technologies, 31 transhipment technologies are identified, but as some technologies are either to be phased out, have not been fully developed or have not seen wider market deployment for other reasons, in the end 16 distinct transhipment technologies are analysed in relation to their applicable modes of transport and different intermodal loading units. The loading units assessed are the 20' container, 40' container, craneable and non-craneable semi-trailer as well as truck and trailer combinations.

[1] Policy scenarios for delivering the European Green Deal | Energy (europa.eu)
[2] REFIT Ex-Post Evaluation of the CT Directive 92/106/EEC in 2016; https://ec.europa.eu/transparency/documents-register/detail?ref=SWD(2016)140&lang=de

Table: Overview of transhipment technologies and their short description

	Transhipment Technology (promoter)	Short description
1	Gantry Crane	A crane for handling intermodal loading units which is built on a gantry, which spans over the workspace beneath and possibly to the left and right of the gantry using cantilevers. They usually move along rails (Rail Mounted Gantry Crane / RMG) or tracks (Rubber Tyred Gantry Crane / RTG).
2	Reach Stacker	A rubber tyred vehicle used for the handling of intermodal loading units using a lifting arm.
3	Hydraulic Material Handling Crane	A mobile crane capable of rotating on its base and using a hydraulic lifting arm for lifting loading units or other objects.
4	Mobile Harbour Crane	A mobile crane capable of rotating on its base and using hoist ropes, wire ropes or chains and sheaves for the lifting of loading units or other objects.
5	RoRo Ramp to/from Ship	A ship using ramps over which wheeled cargo can be loaded or unloaded.
6	Sidelifter	A chassis mounted device used for the direct transhipment of loading units between the chassis and the ground, rail wagons or another chassis.
7	BOXMover	A brand and specific type of a sidelifter with some technical differences developed by the company BOXmover.
8	Mobiler (Rail Cargo Austria)	A horizontal loading technology for specifically designed loading units and brand of Rail Cargo Austria.
9	Container Mover 3020 (Innovatrain)	A horizontal loading technology for swap-bodies and containers and brand of the company Innovatrain.
10	Cargo Beamer next generation (Cargobeamer AG)	Horizontal transhipment system for "non-craneable" semi-trailers with terminal installation and specifically designed wagon. Product and brand of the company CargoBeamer.
11	Modalohr UIC (Lohr Industrie, VIA)	Horizontal transhipment system for semi-trailers with terminal installations and specific wagons. Product and brand of the company LOHR.
12	Nikrasa (TX Logistik)	A platform for craning "non-craneable" semi-trailers in pocket wagons (promoted and used by TX Logistik). A corresponding terminal platform is required.
13	ISU (ÖBB Rail Cargo Austria)	A technology consisting of a ramp in terminals and beams attached to ropes to load "non-craneable" semi-trailers into pocket wagon (promoted and used by Rail Cargo Austria).
14	RoLa Ramp	A technology for the transport of full vehicles on specially designed rail wagons with the truck driving onto the train via. a ramp.
15	Flexiwaggon	A special type of rail wagon which turns out for the loading/unloading of full vehicles. Product and brand of the company Flexiwaggon.

16	r2l 2.0 road rail link (VEGA)	A platform for craning "non-craneable" semi-trailers in pocket wagons (promoted and used by VEGA Trans, VTG and TX Logistik).

A total of 39 different transhipment technology, loading unit and mode of transport combinations were included in the further analysis.

For each of these combinations technical and financial data was gathered in interviews with technology providers and users. This included detailed data about the capabilities (transhipable loading units, max. transhipable weight), the transhipment process (terminal layout, processing times, necessary personnel, necessary equipment) and the technology specific equipment (performance indicators, investment costs, operational costs). With the gathered data, two model transport chains were set up for transporting 20 t of freight in one loading unit over total distances of 600 km and 1 000 km, with two road legs of 75 km. Based on these assumptions the terminal handling capacity, transhipment and transport durations, terminal building costs, transhipment and transport costs as well as external costs of transport were modelled for each combination. The outcome of this modelling, including an estimated costs range per transhipment taking into account the European differences in construction, energy and labour costs, is presented in comprehensive fact sheets for each transhipment technology, loading unit and main leg mode of transport combination.

In addition, the study outlines the process to be followed in order to put a new loading unit on the market or to introduce a new transhipment technology.

TEN-T NETWORK AND INTERMODAL TRANSPORT

Having analysed and described the different types of loading units and transhipment technologies in detail, the study then looks at the interplay between the existing European (and Swiss) intermodal network and the various transhipment technology and loading unit combinations.

First, the number of intermodal terminals per technology and loading unit combination in the EU was assessed to be around 1 028. Unfortunately, the data available was not sufficient to provide exact numbers of intermodal terminals per transhipment technology and loading unit combination. In particular, for widespread vertical transhipment technologies like gantry cranes and reach stackers, it was possible to identify only a sample of terminals. However, this wide range is still sufficient to show clear differences in magnitude between these mainstream technologies (hundreds of terminals in the EU and Switzerland) and the less widespread technologies (often single-digit or low double-digit terminal numbers).

Based on the numbers of intermodal terminals, the handling capacity per technology and loading unit combination was estimated, using the handling capacity of the model terminals used in the respective fact sheets. The total transhipment capacity in EU is estimated to be in the range of 89 to 168 million loading units, with the majority of the capacity being with main vertical transhipment technologies' (cranes, reach stacker; ~60-80%) and RoRo ships (~20-35%) and only around ~2% total in other technologies. These figures are to be understood to only provide an order of magnitude of the handling capacity per technology and loading unit combination and not an exact assessment of the actual handling capacity, in particular for the widely used technologies, and the upper limits are possibly overestimated. Similarly, an estimation of current use (i.e. the actual use of available capacity) of each technology-loading unit combination was carried out and it results in an estimation that today around 100 million loading units are transhipped yearly, with around 75% being transhipped by main vertical transhipment technologies.

The study then looks at the prevalence of these technology-loading unit combinations on the nine TEN-T Core Network Corridors. This analysis included two parts, the first determining the number of intermodal terminals on each TEN-T corridor and the second determining the corridors, or parts of the corridors, on which the specific technologies where used. In total, 141 ports and 108 rail-road-terminals were identified on the TEN-T corridors (using TENtec portal database), while 324 terminals were identified for the rail freight corridors from the rail facilities portal database; given that the two networks often overlap, some of the terminals are counted two times. As for different technologies, the standard vertical transhipment technologies and the RoRo technology were identified to be used on all nine corridors, while each of the less widespread technologies are used on between zero up to six of TEN-T corridors.

The study further focuses on the TEN-T network to identify existing limitations specific to intermodal transport and concludes that the main limitation was the clearance gauge. Namely, when taking into account the dimensions of standard wagon, loading units and any necessary auxiliary equipment, then operations involving 4m high semitrailers on standard pocket wagons will require the rail infrastructure to be sufficiently large to allow the use of P400 profile trains without further calculations in daily operations. The study analysed the network to establish the number of kilometres unsuitable for semitrailers on train due to the fact that it is not possible to operate P400 profile trains on these network sections. This included six country-specific case studies (Italy, Czechia, France, Spain, Slovenia and Bulgaria). The data on codification of clearance gauge P400 in TENtec and RINF databases and subsequent interviews with infrastructure managers show that 52% of TEN-T rail corridors length is not compliant with P400. However, it should be pointed out that, firstly, the data in these databases is not complete nor exact and, secondly, that a limiting codified clearance gauge does not necessarily mean that semitrailers cannot pass. Quite often lines that are not codified for the P400 profile can currently accommodate the passage of intermodal trains with P400 profile. Therefore the stakeholders were consulted on actual problems for running semitrailers on standard pocket wagons on different parts of the TEN-T network, and the resulting updated estimation is that 14 879 km of TEN-T sections include specific objects and places where structural upgrading work is necessary. Most importantly, most upgrades are necessary in Spain, France and Italy, which together amount to 75% of sections that need to be upgraded).

The study then analyses the different types of structural interventions required to ensure that semi-trailers could be used on a particular section. Four different types of intervention can be identified. For sections where a gap exists between the current coding of the line and the actual gauge (ability to pass), recodification of the line could be carried out with costs that are considerably lower than three other identified interventions, which are structural. Based on previous task, comparing the data available in databases and provided by infrastructure managers with the information from stakeholders, it can be assessed that ca 7 127 km of network would require either updating data in databases or recodification. As for structural interventions, the study describes three different types of interventions (tunnel vault works, roadbed lowering or using a third track) and suggests an alternative to use lower wagons that require smaller gauge (such as wagon with a 27 cm platform height, e.g. T3000, T5 or TWIN wagons, Cargobeamer or Modalohr wagons).

As the next step, the investment cost needed to remove these limitations on the TEN-T corridors is estimated. As the previous analysis did not allow for the identification of specific infrastructure limitations (tunnels, bridges, etc.) three cost scenarios were used resulting in total cost of upgrading the entire TEN-T Corridors to allow for the operation semitrailers on trains between EUR 3 124 M and EUR 14 879 M. According to the medium scenario the overall cost would be equal to EUR 5 118 M.

As regards network capacity, general capacity limitations of road, rail and inland waterway exist on the main north-south corridors, both on sections and nodes. This is particularly the case in Alpine crossing, where traffic is concentrated on a few arteries and in certain urban nodes where local, regional and long-distance traffic uses the same infrastructure. Intermodal transport, which requires the consecutive use of those infrastructures, suffers from the same capacity limitations. If the capacity for rail and inland waterway is not increased where necessary, additional traffic cannot be realised and modal shift options may not be exploited to their full potential. Further specific study on intermodal capacity may not be meaningful for infrastructure with a mixed use: it is rather more important to consider the growth potential of intermodal transport in the capacity planning to rail, road and inland waterways.

A next step identifies the investment costs associated with the construction of enough intermodal terminals to make each technology fully operational in all TEN-T Core Network Corridors. The minimum number of terminals required on a corridor was estimated with a terminal every 850 km of corridor length. The unit cost of the construction of a new terminal were calculated for the model terminals and presented in the fact sheets. The analysis of overall terminal investment need, composed of the construction of new terminals, including infrastructure and superstructure, and upgrading of existing terminals, is EUR 2 617 M.

To conclude, the removal of network limitations per each TEN-T corridor by considering both the costs of upgrading the rail network to allow the transport of semi-trailers and the costs for the upgrade and construction of new terminals, results in an investment need of about EUR 7 735 M.

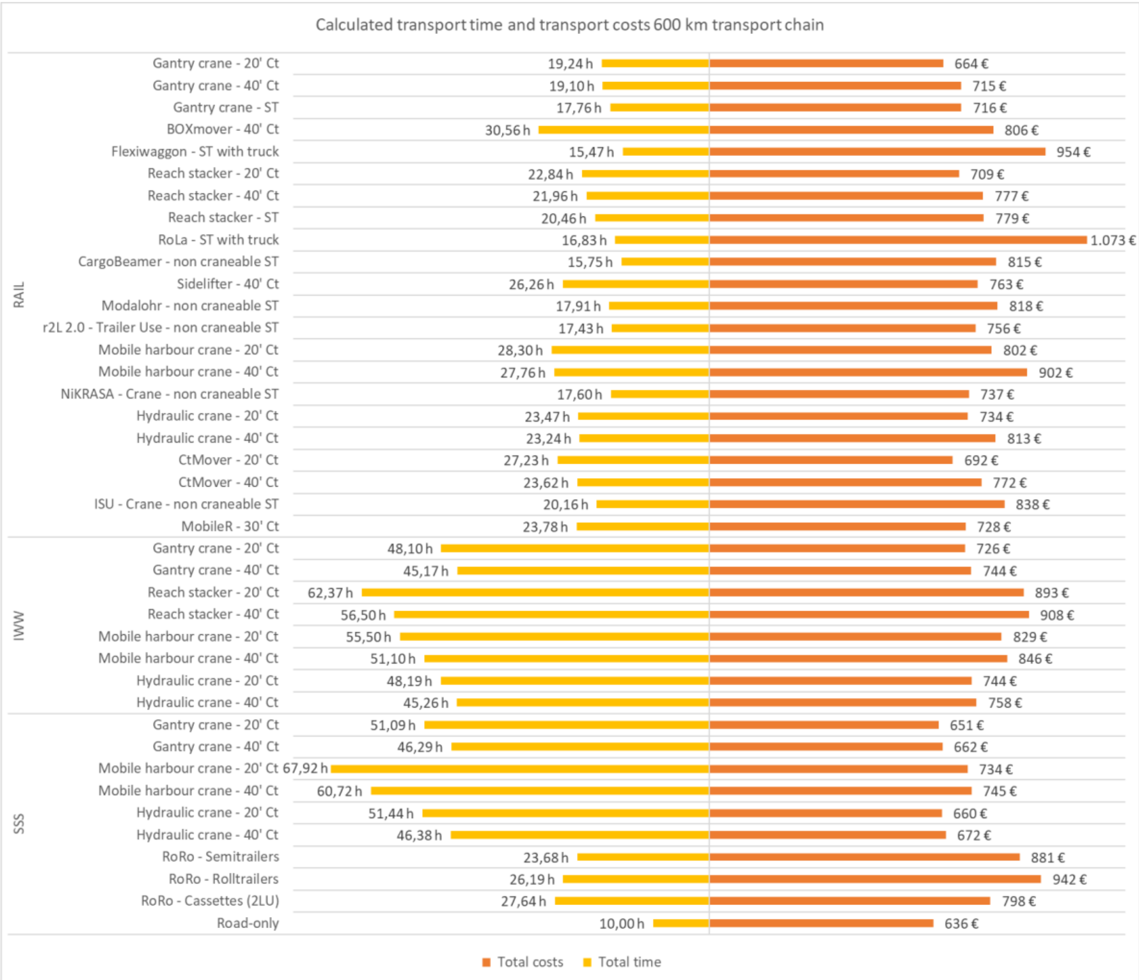
Following the assessment of today's limitation, the study looks at the projected terminal and network capacity by 2030. It estimates that, based on current plans for upgrade and construction, the overall EU terminal transhipment capacity will increase by 18% by 2030 or to an estimated potential terminal handling capacity of roughly 308 million LU/year. This assessment may be an overestimate. As for network capacity, it is estimated that many of the bottlenecks will not be removed by 2030 and thus the EU core transport network will not reach its full capacity by 2030. However, the Smart and Sustainable Mobility Strategy establishes a goal of increasing the rail and waterborne transport capacity by 2030 by 50% and 25% respectively. When comparing this desired increase with the 18% expected increase in transhipment capacity by 2030 and taking into account that today's terminal capacity estimates are likely to be overestimated, it is clear that the transhipment capacity available in 2030 is likely to be too low compared to network capacity, which in turn would mean that the network is not used to its full potential.

COMPARATIVE ANALYSIS

The final part of the study compares the technology-loading unit combinations within each other and with road-only transport. The results of the comparison are influenced by the model assumptions and thus changing any of the parameters or assumptions can change the outcome of the comparison. The comparison is thus not directly applicable to all specific real-life situations. Furthermore, to facilitate the comparison, the road-leg costs determined in the fact sheets were supplemented by a flat charge depending on the type of loading unit to account for additional deployment and handling costs of the loading units at each end of the intermodal transport chain. The cost calculation assumes no financial support for building intermodal terminals.

The first comparison is based on the comparative costs of the model transport chain over 600 km and 1 000 km. The results show that, for the 600 km transport chain, none of the transhipment technology and loading unit combinations can achieve costs at or below the level of the road-only transport. The lowest comparative costs among the intermodal transport chains are achieved by the gantry crane technology and container combination for each mode of transport. For the 1 000 km distance the comparison is different and 30 of the 39 analysed combinations achieve lower comparative costs than road-only for the model transport chain. Only for accompanied intermodal rail transport each additional kilometre travelled on rail is more expensive than if it were on the road. In the comparison of costs between different loading units for the same technology, the container is calculated to be the most economical under the model assumptions. When comparing different semitrailer technologies, vertical craning of the semi-trailer has lower costs compared to horizontal transhipment. Intermodal chains for “craneable” semi-trailers are cheaper than those using “non-craneable” semi-trailers. As regards duration, all intermodal operations take longer than road-only transport on both distances and it is the technologies with full road vehicles and horizontal transhipment that have the best transport times for both distances. Also, rail related operations are on average faster, followed by Ro-Ro operations, while inland waterway and container short sea shipping are considerably slower. For rail, the duration is mainly influenced by the main leg duration and thereby the trains average speed, for which a conservative assumption of only 40 km/h was made.

Figure: Calculated transport time and cost for a 600 km door-to-door transport by different forms if intermodal and road-only transport (Ct = Container, ST = semitrailer)



Secondly, the study analyses the competitiveness of different combinations and road-only transport based on weighted scoring model with four criteria: costs, duration, availability of terminals and network coverage of respective services. Similarly to cost calculation at 600 km, all technologies are less competitive than road-only transport. At 1 000 km, gantry crane/reach stacker with containers can compete with road-only transport.

As next step, the study evaluates how suitable different transhipment technology-loading unit combinations are for modal shift. Again a weighted scoring model was used for the assessment based on the criteria of the previously calculated competitiveness score, network limitations for specific technology-loading unit combinations on the TEN-T core network corridors based on loading gauge and the flexibility to use the technology and loading unit combination with other technologies and loading units. The comparison shows that standard vertical transhipment technologies, especially the gantry crane technology with containers, are best suited to foster further modal shift. However, it should be kept in mind that different demand side aspects and conditions on particular parts of the network may change the circumstances and shippers and logistics service providers may prefer other loading units and compatible transhipment technologies in different situations. When applying the external costs of different modes of transport as established in the Handbook of external costs in transport to different technology-loading unit combinations, the potential to save external costs on modelled 600 km and 1 000 km operation based on the 2030 modal shift potential can be calculated for each combination. This potential is strongly dependent on the mode of transport used and the transport efficiency of the technology and loading unit combination.

Finally, total costs, that is total comparative costs with the external costs included, were compared for all intermodal and road-only transport chains. The external cost calculations take into account the tkm, the external unit costs for rail, inland waterway, short sea shipping or road-only transport presented in the Handbook.[3] In order to take into account the different tare weight of vehicles, auxiliary equipment and loading units the calculation was not applied to the net tons transported but the gross tons. Loading unit transhipment technology combinations which are carrying a lot of equipment and not much net tons perform worse than those technologies with a low equipment weight.

The results show that already for the 600 km transport 32 of the 39 intermodal transport chains would have lower total costs than road-only transport if external costs were internalised. For the 1 000 km transport chain, this number increases to 37 out of 39 intermodal transport chains. The two technologies with higher total costs than road-only transport, even when external costs are accounted for, are the two accompanied (full road vehicle) intermodal rail transport choices, due to the high total system costs. When comparing only external costs, all transhipment technology and loading unit combinations were calculated to have lower external costs than road-only transport over both transport distances.

[3] Handbook on External Costs 2019; https://op.europa.eu/de/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1

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